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(71)出願人　000128496
株式会社オーク製作所
東京都調布市下石原一丁目２番地３

(72)発明者　石飛　学
山口県宇部市常盤台２－16－１　山口大学内

(72)発明者　篠木　晟
長野県茅野市玉川4896　株式会社オーク製作所諏訪工場内

(74)代理人　100099254
弁理士　役　昌明　（外３名）

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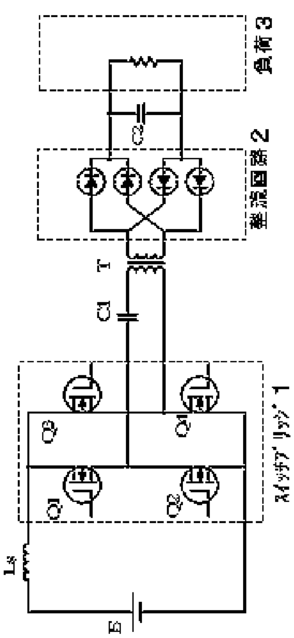
(54)【発明の名称】　電流共振型ソフトスイッチング電源回路

(57)【要約】
【課題】　電流共振型ソフトスイッチング電源回路において、トランスの２次側に整流回路やマグネトロンがあってもソフトスイッチング出来るようにする。
【解決手段】　商用交流電源を整流して直流電源Ｅとする。直流電源Ｅに、インダクタンス素子Ｌsと、ブリッジ接続スイッチング回路１とを直列に接続する。ブリッジ１の第１アームの接続点に、コンデンサＣ１を介してトランスＴの１次コイルの一端を接続する。トランスＴの１次コイルの他端を、第２アームの接続点に接続する。トランスＴの２次コイルに、整流回路２と平滑コンデンサＣ２とを接続する。一定のデッドタイムを含めて、デューティ比が0.5となるように、ブリッジ接続スイッチング回路１をON／OFF駆動する。駆動信号の繰返周期を変化させることで、出力電力を制御する。



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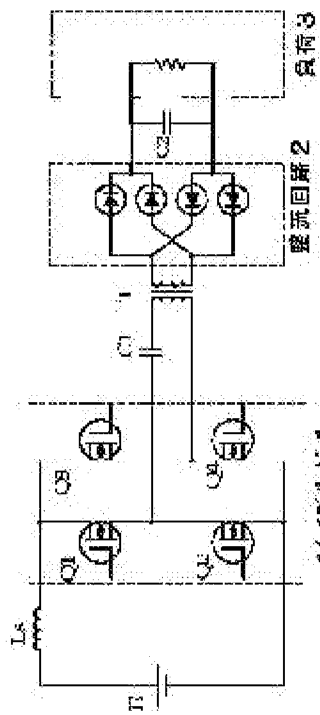
(71)Applicant : ORC MFG CO LTD

(72)Inventor : ISHITOBI MANABU
SHINOKI AKIRA
ADACHI NOBUO

(54) CURRENT RESONANCE TYPE SOFT SWITCHING POWER CIRCUIT



(57)Abstract:

PROBLEM TO BE SOLVED: To enable soft switching in a current resonance type soft switching power circuit even if there is a rectifying circuit or a magnetron on the secondary side of a transformer.

SOLUTION: Commercial alternating-current power is rectified to obtain direct-current power E. The direct-current power supply E is connected in series with an inductance element Ls and a bridge-connection switching circuit 1. The junction of a first arm of a bridge 1 is connected with one end of a primary coil of the transformer T through a capacitor C1. The other end of the primary coil of the transformer T is connected with the junction of a second arm. A secondary coil of the transformer T is connected with the rectifying circuit 2 and a smoothing capacitor C2. The bridge-connection switching circuit 1 is on/off-driven so that a duty ratio, including a certain dead time, is 0.5. By varying the cycle period of a driving signal, output power is controlled.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]Especially this invention relates to the current resonance type soft switching power supply circuit of a frequency variable which has few additional components and where a principle of operation is comparatively easy about a current resonance type soft switching power supply circuit.

[0002]

[Description of the Prior Art]It is important to lessen the loss accompanying switching of a solid state switch in the switch-mode power supply for power controls in order to improve efficiency. Generating of a noise is controlled and to consider it as the circuit which does not spoil electromagnetic environment is demanded. For this purpose, by the timing of current zero or voltage zero, a means to perform switch ON/OFF is taken in and this is called soft switching.

[0003]It is a technical technical problem how soft switching is performed. It is soft switching and there are various proposals, such as a method in which power controls are possible, by the method of making clock frequency variable, and the soft switching which fixed frequency for power controls. It will be necessary to make it operate by audio frequency, and the problem of a noise generation will arise in the method which makes clock frequency variable for power controls.

[0004]The "zero-electric-current switch pulse-frequency-modulation type (ZCS-

PFM) high frequency link DC DC converter circuit" which is one method of a soft switching circuit, It has a large soft switching zone by small lightweight and low cost, and since it is simple circuitry, it has the outstanding feature that it is reliable, and is used by high-frequency-induction heating apparatus etc. On the other hand, the fault that it will be large and oscillating frequency will go into an audio frequency range at the time of a low power output also has a current peak which flows through a switching device.

[0005]A high frequency link ZCS-PFM series resonance type DC-DC converter, In current discontinuity mode (switching frequency is less than [of resonance tank character frequency] 1/2), ZCS (zero-electric-current switch) is performed at the time of turn-on, and ZCS and ZVS (zero voltage switch) operation are performed at the time of a turn-off.

[0006]Only when so small that the current discontinuity mode can disregard the exciting current of a high frequency transformer, it is realized. In order to make an exciting current small, the voltage generated in a primary high frequency transformer side must be stopped low. Therefore, in order to fulfill this condition in the application which requires high tension of an output, it is necessary to enlarge the winding ratio of a high frequency transformer. However, if the high frequency transformer of a high winding ratio is used, weak points, like becoming what cannot disregard the parasitic capacitance between the secondary winding of a transformer, and big current flows into a primary transformer side at the time of a big-electric-power output will arise.

[0007]In order to control output power by the series resonance form DC-DC

converter of current discontinuity mode, switch ON time is kept constant to the value which becomes the best for the resonance state, and an output is controlled by changing a cycle. Therefore, in order to bring an output close to zero, frequency must be brought close to zero and the weak point included in an auditory area arises.

[0008]The circuit diagram of the conventional current resonance type soft switching power supply circuit is shown in drawing 17. The load 3 is resistance or equivalent devices (high frequency heating coil etc.). The circuit which expressed the transformer of this circuit in the equivalent circuit is shown in drawing 18. In this circuit, when Q1 and Q4 are ON, Q2 and Q3 are OFF, and when Q2 and Q3 are ON, Q1 and Q4 become OFF. The drive timing of this circuit is shown in drawing 19. When Q1 and Q4 are ON, the current from the DC power supply which rectified commercial power flows through Q1-C-Ll-load R-Q4. At this time, the capacitor C and the leakage inductance Ll of a transformer resonate, and current as shown in drawing 20 flows.

[0009]The waveform a shown in drawing 20 shows the current into which a solid line flows through Q1 and Q4, and a dotted line shows flywheel diode current. The waveform b shows a gate drive signal waveform. If Q1 and Q4 turn on at the time t1, current will begin to increase and will serve as an oscillatory wave form by the series resonance of the capacitor C and the inductance Ll. If direction of current changes at the time t2, current will flow through the flywheel diode (or diode connected in parallel) built in the switch element. Current does not flow into a switch element after t2.

[0010]If the current of this switch element switches off during the zero (current is flowing into the flywheel diode), a zero-electric-current switch (ZCS) is realizable. The period from t1 to t2 is decided by resonance by the capacitor C and the inductance Ll. Therefore, time to set Q1 and Q4 to ON is fixed to time a little longer than (t2-t1). At the arbitrary time t3 after t2, the remaining half cycles are continued by setting Q2 and Q3 to ON.

[0011]In this circuit, load is resistance (or equivalent thing) and the resonance state does not change with time. Since the impedance of the magnetization inductance of a transformer is large compared with load resistance, switching is not usually influenced. Output power controls a switch by the change in the repetition carried out to one. Therefore, after the time according to output power passes after t3, the operation which considers a switch as one is repeated. This time corresponds to Toff shown in drawing 19.

[0012]

[Problem(s) to be Solved by the Invention]However, in the conventional current resonance type soft switching power supply circuit, when a rectification circuit is connected as load, there is a problem that a zero-electric-current switch is unrealizable. A resistance load or a heating coil of the conventional circuit is effective when impedance does not change, but a problem occurs in the circuit which makes load the rectification circuit which has a smoothing capacitor, for example, the circuit which includes a rectification circuit in the secondary of a transformer as shows drawing 21.

[0013]In a circuit including a rectification circuit, the period when current flows

between one cycles of exchange, and the period not flowing arise. Current will not flow into the secondary coil of a transformer in the period when the voltage of the secondary of a transformer becomes low from voltage VL accumulated in the smoothing capacitor. As shown in drawing 22, it is set to ON by t1, and the resonance current of the capacitor C1 and the leakage inductance Ll of a transformer flows in the state where current flows into the rectification circuit of the secondary of a transformer. If the resonance voltage induced by the secondary of a transformer is lower than the voltage of the smoothing capacitor C2, current does not flow into the secondary coil of a transformer, but it will be in the state where impedance is high. In this state, the current which it becomes impossible to disregard the impedance of the magnetization inductance of a transformer, and flows through a switch element turns into the resonance current which flows through magnetization inductance through the series circuit of the leakage inductance of the capacitor C1 and a transformer. This state becomes t2' of drawing 22 or subsequent ones.

[0014]In the state where the resonance current flows through the magnetization inductance of a transformer, since magnetization inductance is large, resonance frequency becomes quite low. Therefore, it becomes quite late that it will be in the state where the current which flows through a switch element turns off and current flows into a flywheel diode compared with a conventional example. For this reason, when the rectification circuit was conventionally connected as load with the circuit and the switch drive method, there was a problem that a zero-electric-current switch was unrealizable.

[0015]This invention solves the above-mentioned conventional problem, and an object of this invention is to enable it to realize soft switching, even when it includes a rectification circuit as load in the current resonance type soft switching circuit which changes frequency and performs power controls.

[0016]

[Means for Solving the Problem]A semiconductor switching circuit connected to a DC power supply part and a DC power supply part via a snubber inductor in this invention in order to solve the above-mentioned technical problem, It prepares for resonance capacitors connected to a semiconductor switching circuit, resonance capacitors, and a semiconductor switching circuit with a transformer to which a primary coil was connected, In a current resonance type soft switching power supply circuit which supplies electric power to nonlinear load connected to a secondary coil of a transformer, So that a duty ratio of current which drives a resonant circuit of a primary coil of a transformer and resonance capacitors may be set to 0.5 including a fixed dead time, It had composition possessing a driving means which carries out the ON/OFF drive of the semiconductor switching circuit with a driving signal of an opposite phase mutually, and a means to control output power by changing a cycle period of a driving signal.

[0017]By having constituted in this appearance, soft switching is realizable also in a circuit which supplies electric power to nonlinear load of a rectification circuit etc.

[0018]

[Embodiment of the Invention]Hereafter, an embodiment of the invention is

described in detail, referring to drawing 1 - drawing 16.

[0019](Embodiment) The duty ratio of the driving signal of the switching circuit which an embodiment of the invention forms a resonant circuit by the inductance and the capacitor of a transformer, and excites a resonant circuit including a dead time as about 50%, It is a current resonance type soft switching power supply circuit which drives the load in which the rectification circuit was included.

[0020]Drawing 1 is a circuit diagram of the current resonance type soft switching power supply circuit in an embodiment of the invention. In drawing 1, DC power supply E carry out rectification smooth [of the commercial alternating current], and use it as DC power supply. The snubber inductor Ls is a lossless inductor snubber of the comparatively small inductance for setting to about 0 voltage impressed to a switch at the moment of a switch change. The switch bridge 1 is the bridged circuit which carried out multiple connection of the switch element Q1 which consists of FET or IGBT, the series connection circuit of Q2, and the series connection circuit of Q3 and Q4. The capacitors C1 are resonance capacitors which constitute a series resonant circuit from leakage inductance of a transformer. The transformer T is a means which carries out pressure up of the volts alternating current. The rectification circuit 2 is a circuit which changes exchange into pulsating flow. The smoothing capacitor C2 is a capacitor for making pulsating flow a direct current. The loads 3 are load circuits, such as a magnetron.

[0021]Drawing 2 is a figure showing the state of t1-t2 of the current resonance type soft switching power supply circuit in an embodiment of the invention.

Drawing 3 is a figure showing the state of t2-t3 of a current resonance type soft switching power supply circuit. Drawing 4 is a current wave form figure of the resonant circuit of a current resonance type soft switching power supply circuit. It expresses without distinguishing the current which flows through a switch element, and the current which flows through a flywheel diode. Drawing 4 (a) is current which flows through Q1 and Q4. Drawing 4 (b) is current which flows through Q2 and Q3. What was built in FET may be sufficient as a flywheel diode, and what carried out external in parallel with a switch element may be sufficient as it. Drawing 5 is a figure showing the state of t4-t5 of a current resonance type soft switching power supply circuit. Drawing 6 is a figure showing the state of t5-t6 of a current resonance type soft switching power supply circuit.

[0022]Drawing 7 is a figure showing the solid state switch drive timing of the current resonance type soft switching power supply circuit in an embodiment of the invention. In drawing 7, dead-time DT is the driving stoppage time for keeping penetration current from flowing. Drawing 8 is a graph which shows the relation of the voltage between anode cathodes and anode current of a magnetron. Drawing 9 is a graph of the magnetron output to the clock frequency of a current resonance type soft switching power supply circuit.

[0023]Drawing 10 - drawing 12 are the figures of the circuit which used the half bridge for the current resonance type soft switching power supply circuit in an embodiment of the invention. Drawing 11 is the circuit diagram which combined the voltage doubler rectifier circuit as a rectification circuit. Drawing 12 is a circuit diagram at the time of combining magnetron load, and has shown load in the

equivalent circuit. Drawing 13 is the circuit diagram which added the auxiliary inductor to the current resonance type soft switching power supply circuit. Drawing 14 is a comparison figure of the switch driving waveform of this invention and a conventional example.

[0024]Drawing 15 is a circuit diagram in the case of impressing pulsating flow to load without using a smoothing capacitor for the current resonance type soft switching power supply circuit in an embodiment of the invention. Drawing 16 is a circuit diagram in the case of impressing alternating current to the load of a self-rectification method directly without using a rectification circuit for a current resonance type soft switching power supply circuit.

[0025]Operation of the current resonance type soft switching power supply circuit in the embodiment of the invention constituted as mentioned above is explained. First, fundamental operation of a circuit is explained with reference to drawing 1. The feature of this circuit is that it resonates with the point that the snubber inductor Ls is inserted, and the leakage inductance or magnetization inductance of the capacitor C1 and the transformer T. The role of leakage inductance and magnetization inductance changes by the relation between the voltage of load, and resonance voltage. Since there is no rectification circuit in load in the conventional circuit compared with this circuit, there is no influence of magnetization inductance.

[0026]Rectification smoothness of the commercial alternating current is carried out, and it is considered as DC power supply E. The series connection of DC power supply E, the inductance Ls, and the switch bridge is carried out. Multiple

connection of the switch element Q1 which consists of FET or IGBT, the series connection circuit of Q2, and the series connection circuit of Q3 and Q4 is carried out, and a switch bridge is constituted. The series connection circuit of the primary coil of the transformer T is connected with the capacitor C1 between the node of Q1 and Q2, and the node of Q3 and Q4. Load is connected to the secondary coil of a transformer through a rectification circuit and the smoothing capacitor C2. Direct current power is supplied to this load.

[0027]If the switch elements Q1 and Q4 are simultaneously set to ON and Q2 and Q3 are simultaneously set to OFF, current will flow through the primary Q1-C1-transformer coil Q4 from DC power supply E. This state is shown in drawing 2. After this current turns into the resonance current and increases to the maximum with the leakage inductance Ll of the capacitor C1 and the transformer T, it decreases. In process of this reduction, the voltage of the secondary coil of a transformer will fall from the voltage of the smoothing capacitor C2 of an output side, and the current of the secondary coil of a transformer will not flow. At this time, current comes to flow, the inductance, i.e., the magnetization inductance, of a primary coil of a transformer, and a current change serves as the loose resonance current. This state is shown in drawing 3.

[0028]If the direction of the resonance current is reversed by t3-t4 as shown in drawing 4, the voltage where current flows through the switch element Q1 and the flywheel diode built in Q4 (or external) and which is built over a switch element will be in the state where the forward voltage of the flywheel diode was impressed for reverse. And the current which passed along the flywheel diode

turns into regenerative current to the rectification circuit of commercial power through the inductance Ls. If the switch element Q1 and Q4 are turned OFF in this state, a zero current switch is realizable. Then, if Q2 and Q3 are turned ON through a short dead time, the same resonance current as the above will flow through the primary Q3-C1-transformer coil Q2 from DC power supply E. This state is shown in drawing 5. In the process in which this resonance current decreases through the maximum, the current of an output rectifying circuit will not flow and it comes to flow through the magnetization inductance of a transformer. This state is shown in drawing 6. It comes to be able to carry out the switch off of Q2 and Q3 in zero current after time t6. The feature of this driving signal is the point of keeping a dead time constant with the value which secures operational stability of a circuit, changing a cycle, and performing an output control.

[0029]Since there is a period when current will not flow into the rectification circuit of the secondary of a transformer, in the period, the resonance frequency of the primary side circuit of a transformer becomes low. Therefore, compared with a conventional example, time to make a switch off is made late enough. Just before fully delaying the timing which makes a switch off and considering the following opposite switch as one, a dead time required for a change is maintained and it sets to OFF. Namely, as the time t4 of drawing 22 shows, the current (exciting current) which flows through magnetization inductance commutates, and the flowing current should just turn OFF a switch during the zero (current is flowing through the flywheel diode). Since the period when current is flowing into this flywheel diode has large magnetization inductance, it is

comparatively long and the timing where a switch can turn OFF is quite wide. As a result, power controls become possible by fixing the suitable dead time (for example, 10microsec) for the change of a switch, and modulating the pulse width of switch one to the timing shown in drawing 7.

[0030]During [of drawing 4] t1 to t2, electric power is supplied to load through a secondary rectification circuit. Since it is decided by resonance frequency of the capacitor C1 and the leakage inductance Ll of a transformer, this period is not changed freely. On the other hand, after t2, as described above, since current will not flow into a secondary coil and the current of a switch element will not flow by t3, it may switch off in the arbitrary timing of the period to t4 after t3.

[0031]As shown in drawing 8, the magnetron which is a means to generate microwave will be oscillated if a certain amount of high tension is impressed between an anode and a cathode. That is, it oscillates above cut-off voltage. Therefore, a microwave output increases in proportion to anode current above cut-off voltage. If the capacity of the secondary smoothing capacitor of a current resonance type soft switching power supply circuit is chosen appropriately, capacitor terminal voltage, i.e., rectification output voltage, will decrease with the fall of frequency. If it is made for rectification output voltage to turn into cutoff voltage of a magnetron in a place higher than audio frequency as shown in drawing 9, the microwave output of a magnetron is controllable only by the frequency band beyond audio frequency. A noise problem is avoidable by this.

[0032]In the timing of the time t4 shown in drawing 22, when changing a switch, Q1 and Q4 by ON. While the exciting current is flowing through each flywheel

diode, when Q1 and Q4 are turned OFF and Q2 and Q3 are turned ON after dead-time progress, the current revived from the flywheel diode to the rectification circuit of a commercial alternating current will be intercepted. In order to soften sudden change of the current at this time, the comparatively small snubber inductor Ls is inserted between a rectification circuit and a switch bridge. The voltage impressed to a switch by this snubber inductor Ls at the moment of a switch change is set to about 0. As a result, zero voltage switching is realizable.

[0033]As composition of a switch element is not made into bridge connection but it is shown in drawing 10 - drawing 12, it is good also as a half bridge configuration. In this case, the capacity which carried out multiple connection of C1a and the C1b carries out the same work as C1 in bridge composition. Let the rectification circuit 2 be a full wave rectifier circuit in the circuit shown in drawing 10. Let a rectification circuit be the voltage doubler rectifier circuit 5 in the circuit shown in drawing 11 and drawing 12. The equivalent circuit of the magnetron 6 was shown in drawing 12 as load. The capacitor of a voltage doubler rectifier circuit commits the smoothing capacitor C2. Even when composition of a switch element is made into bridge connection, the voltage doubler rectifier circuit 5 can also be used.

[0034]The period which can supply electric power to load is between t1-t2 which are shown in drawing 4, and t4-t5. This period is decided by resonance frequency of the leakage inductance Ll of the capacitor C1 and a transformer. Since the leakage inductance Ll of a transformer is decided by structural factors, such as the winding method of a transformer, it is difficult to use the optimal

value. Then, in order to adjust resonance frequency, as shown in drawing 13, the auxiliary inductor L2 is added to the capacitor C1 in series. What is necessary is just to connect the auxiliary inductor L2 between the node of a capacitor, and a transformer, when a switch bridge is made into a half bridge configuration.

[0035]Comparison with a conventional example explains a switch driving waveform, referring to drawing 14. The drive pulse outputted by turns is summarized to one, and drawing 14 shows it. In practice, it becomes being the same as that of drawing 7 or drawing 19. In the circuit of the conventional example, in order to reduce output power, the number of drive pulses is reduced.On the other hand, pulse width of the drive pulse is lengthened in the circuit in this embodiment.

[0036]This invention is effective as an electric power unit which supplies electric power to the load which is suitable namely, needs a direct current for the use by which a rectification circuit is included in load. When it is the load into which current flows above cut-off voltage like a magnetron, the thing which is an application overlay important point is the comparatively high clock frequency beyond audio frequency, and since an output can be lowered enough, in control of an output, it is that the noise generation of audio frequency is avoided.

[0037]The soft switching operation of switching frequency is attained 1/2 (current continuous mode) or more [of resonance tank character frequency]. Therefore, since the power-factor of the inverter output in the maximum output will become close to 1 if the maximum of switching frequency is set up near the resonance tank character frequency, an electric power capacity factor becomes high and it

becomes possible to reduce the peak value of primary transformer side current of it.

[0038]Although the example which impresses the direct current voltage by which smooth was carried out as an example of a magnetron of operation was explained, as are shown in drawing 15, and shown in the method of impressing pulsating flow, and drawing 16, not using a smoothing capacitor, it is possible to also make it operate by a self-rectification method not passing through a rectification circuit. Even in such a case, on the voltage below cut-off voltage, as for a magnetron, anod resistance becomes large. That is, there is little anodal current to plate voltage. When the resonance voltage of the secondary of a transformer turns into below cutoff voltage of a magnetron, secondary coil current decreases and it becomes impossible therefore, to disregard the magnetization inductance of a primary coil, whether there is no rectification circuit or it uses the rectification circuit which does not contain a smoothing capacitor. As a result, soft switching is certainly realizable by making the duty ratio of a switch driving signal into about 50% including a dead time.

[0039]As mentioned above, in an embodiment of the invention a current resonance type soft switching power supply circuit, Since it had composition which drives the load in which the rectification circuit was included as about 50% including the dead time in the duty ratio of the driving signal of the switching circuit which forms a resonant circuit by the inductance and the capacitor of a transformer, and excites a resonant circuit, An output can be controlled to become low enough, without lowering clock frequency to audio frequency.

[0040]

[Effect of the Invention]So that clearly from the above explanation in this invention. A DC power supply part and the semiconductor switching circuit connected to the DC power supply part via the snubber inductor, It prepares for the resonance capacitors connected to the semiconductor switching circuit, resonance capacitors, and a semiconductor switching circuit with the transformer to which the primary coil was connected, In the current resonance type soft switching power supply circuit which supplies electric power to the nonlinear load connected to the secondary coil of a transformer, So that the duty ratio of the current which drives the resonant circuit of the primary coil of a transformer and resonance capacitors may be set to 0.5 including a fixed dead time, Since it had composition possessing the driving means which carries out the ON/OFF drive of the semiconductor switching circuit with the driving signal of an opposite phase mutually, and a means to control output power by changing the cycle period of a driving signal, The effect that soft switching is realizable for the nonlinear load of a rectification circuit etc. over the wide power-controls range with few additional components also in the circuit which supplies electric power is acquired.

[0041]The effect that an output can be controlled to become low enough without lowering clock frequency to audio frequency like a magnetron especially in the case of load which starts operation above cut-off voltage is acquired.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The circuit diagram of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 2]The figure showing the state of t1-t2 of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 3]The figure showing the state of t2-t3 of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 4]The current wave form figure of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 5]The figure showing the state of t4-t5 of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 6]The figure showing the state of t5-t6 of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 7]The figure showing the solid state switch drive timing of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 8]The graph which shows the relation of the voltage between anode cathodes and anode current of the magnetron connected to the current resonance type soft switching power supply circuit in an embodiment of the invention as load,
[Drawing 9]The graph of the magnetron output to the clock frequency of the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 10]The circuit diagram which used the half bridge switch for the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 11]The circuit diagram which used the half bridge switch and the voltage doubler rectifier circuit for the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 12]The circuit diagram which used the half bridge switch and the voltage doubler rectifier circuit for the current resonance type soft switching power supply circuit in an embodiment of the invention, and connected the magnetron to load,
[Drawing 13]The circuit diagram which added the auxiliary inductor to the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 14]The current resonance type soft switching power supply circuit and the comparison figure of the switch driving waveform of a conventional example in an embodiment of the invention,
[Drawing 15]The circuit diagram in the case of impressing pulsating flow to the magnetron of load without using a smoothing capacitor for the current resonance type soft switching power supply circuit in an embodiment of the invention,
[Drawing 16]The circuit diagram in the case of impressing alternating current to the magnetron which is the load of a self-rectification method directly without using a rectification circuit for the current resonance type soft switching power supply circuit in an embodiment of the invention,

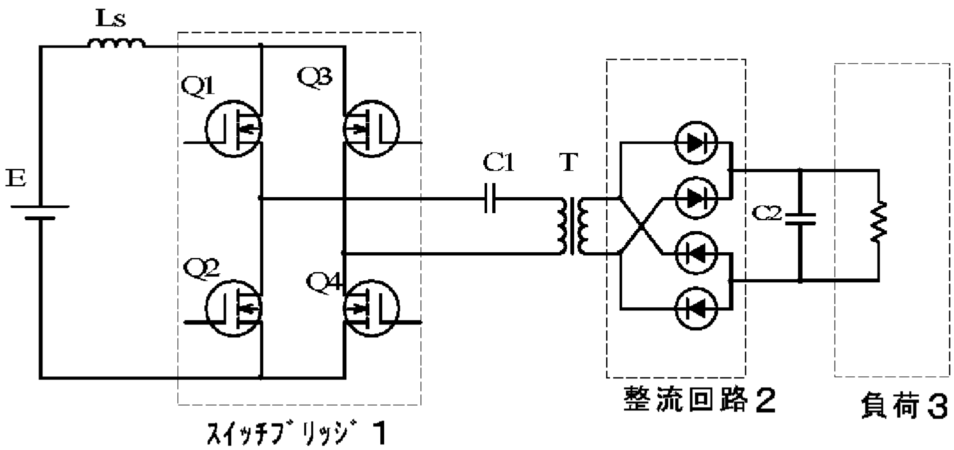
[Drawing 17]The circuit diagram of the conventional current resonance type soft switching power supply circuit,
[Drawing 18]The circuit diagram which expressed the transformer of the conventional current resonance type soft switching power supply circuit in the equivalent circuit,
[Drawing 19]The drive timing diagram of the conventional current resonance type soft switching power supply circuit,
[Drawing 20]The current wave form figure of the conventional current resonance type soft switching power supply circuit,
[Drawing 21]The circuit diagram which connected a rectification circuit and load to the conventional current resonance type soft switching power supply circuit,
[Drawing 22]It is a current wave form figure in the case of including a rectification circuit in the load of the conventional current resonance type soft switching power supply circuit.

[Description of Notations]

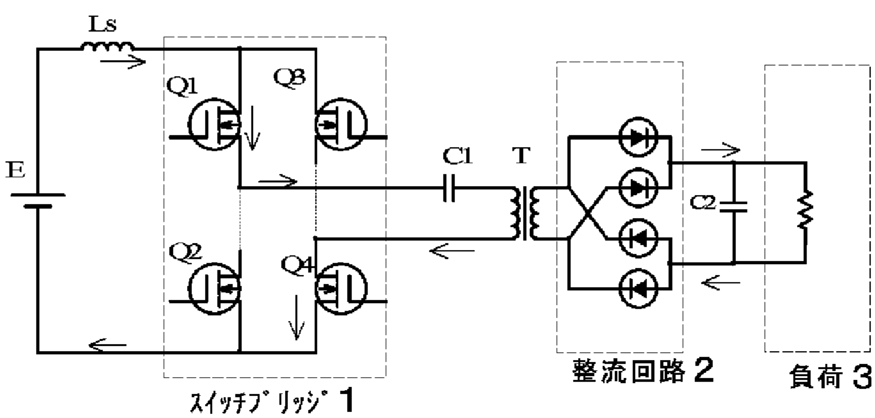
1 Switch bridge
2 Rectification circuit
3 Load
4 Half bridge
5 Voltage doubler rectifier circuit
6 Magnetron
E DC power supply
Ls snubber inductor
Q1, Q2, Q3, Q4 switch element
C1, C1a, a C1b capacitor
T Transformer
C2 smoothing capacitor
L2 auxiliary inductor

DRAWINGS

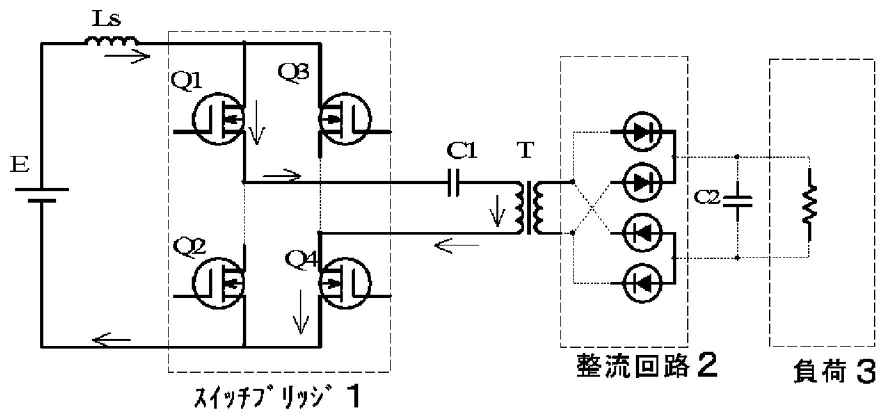
[Drawing 1]



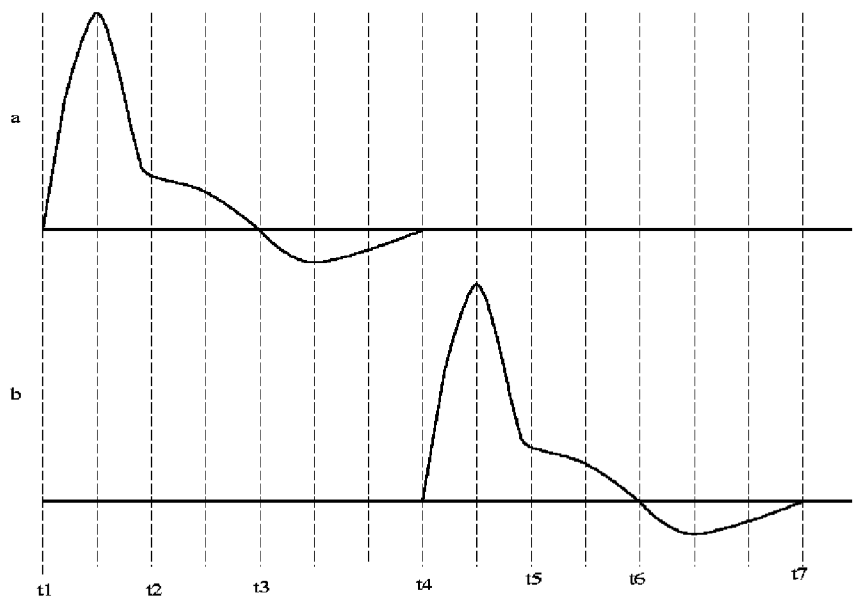
[Drawing 2]



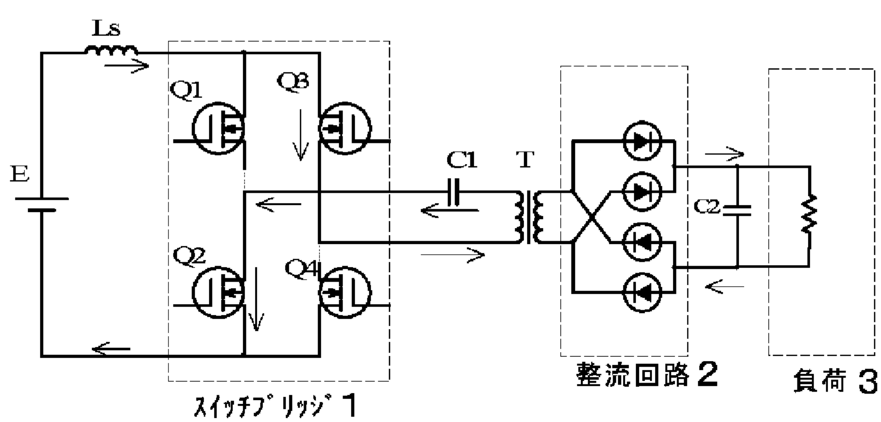
[Drawing 3]



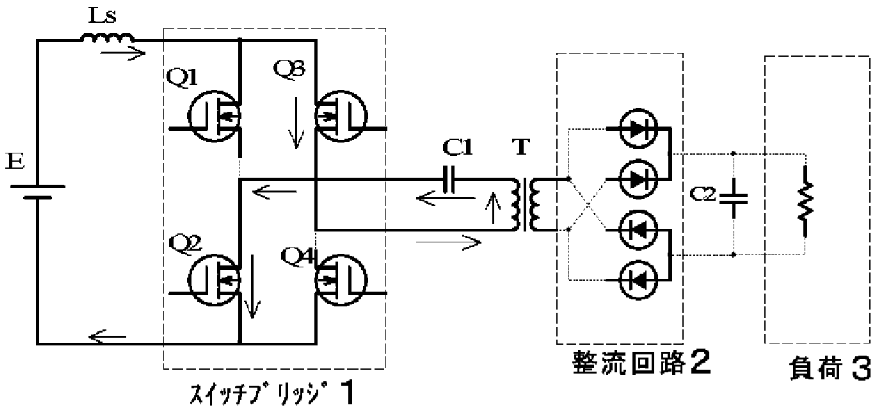
[Drawing 4]



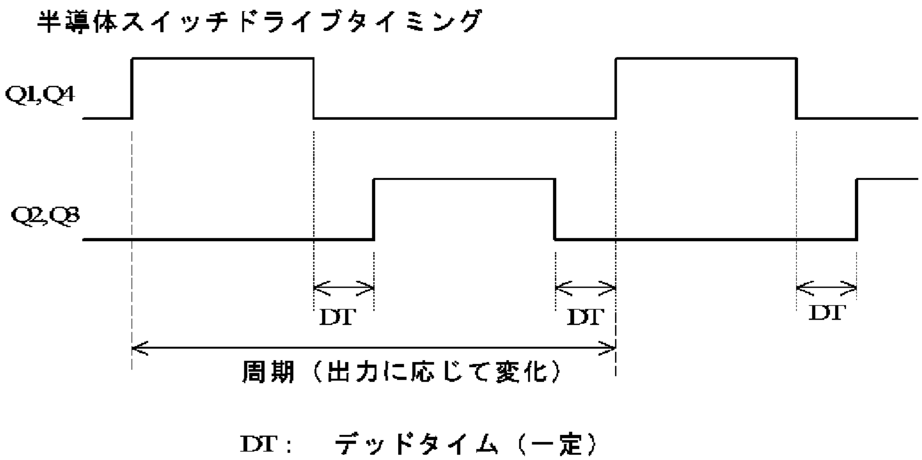
[Drawing 5]



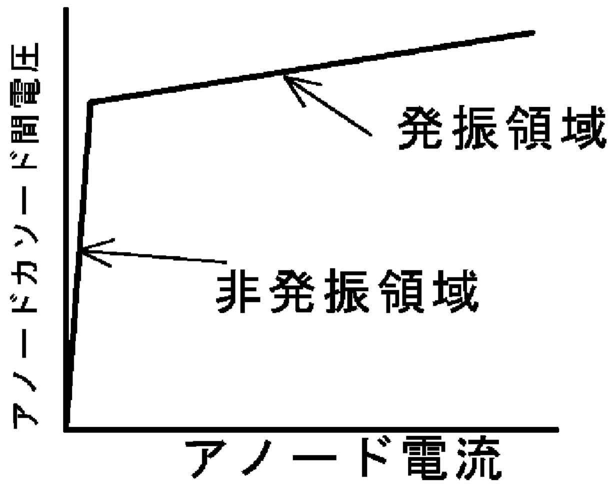
[Drawing 6]



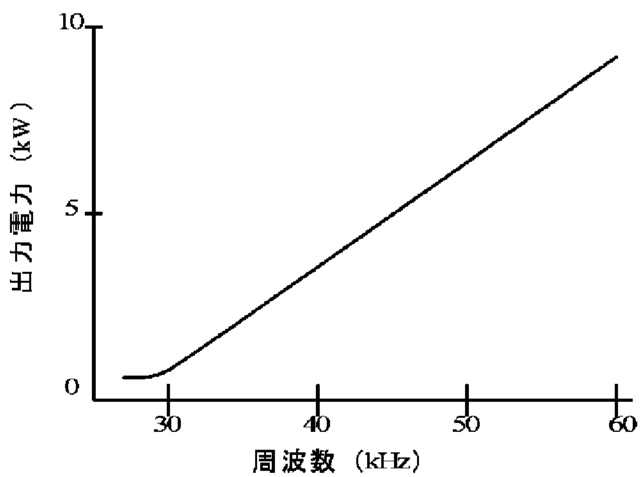
[Drawing 7]



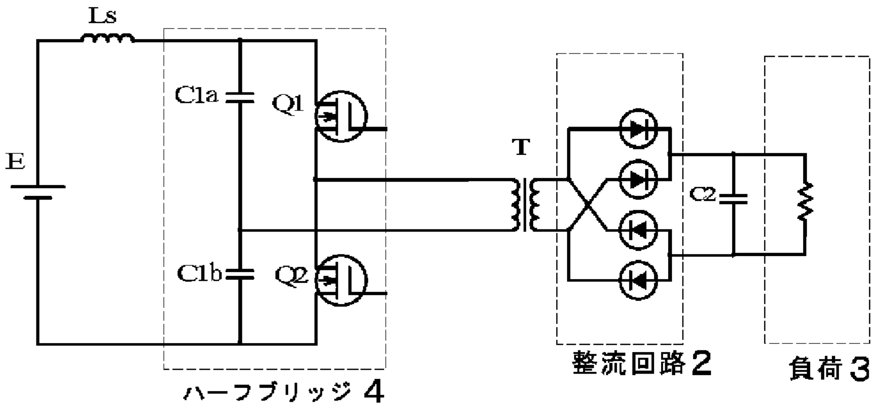
[Drawing 8]



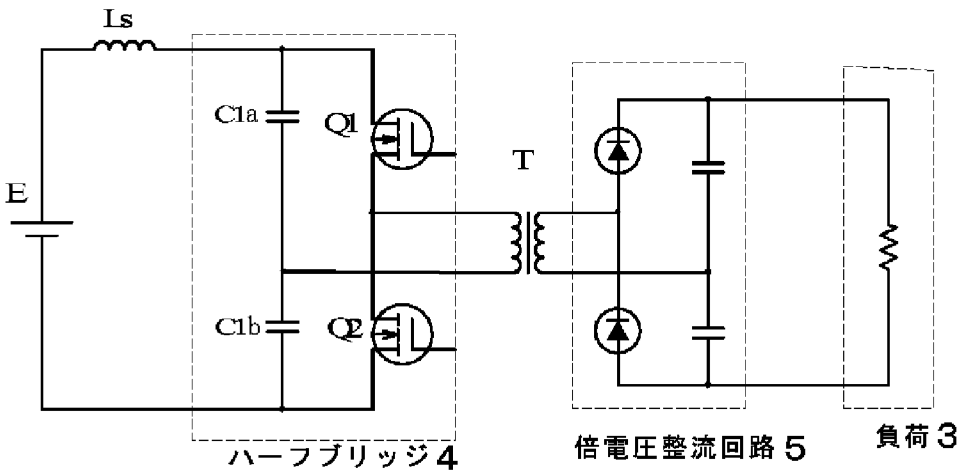
[Drawing 9]



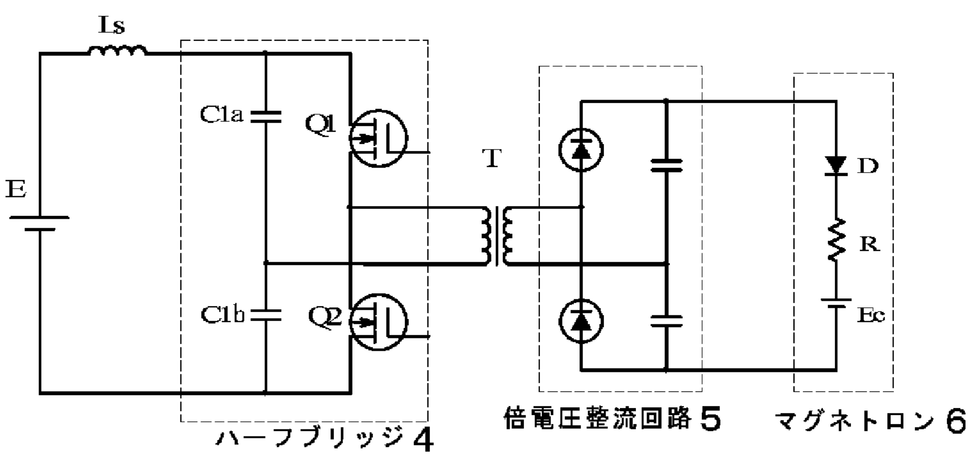
[Drawing 10]



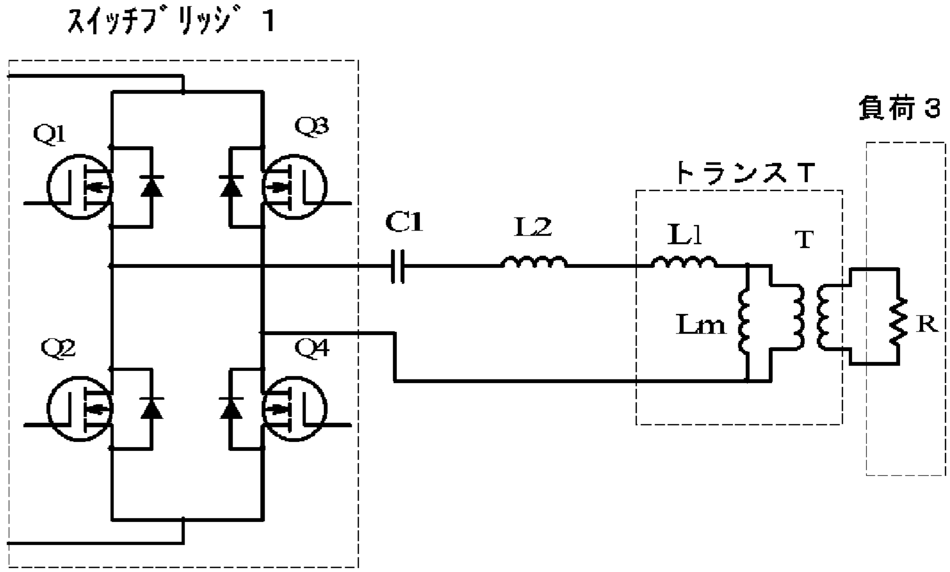
[Drawing 11]



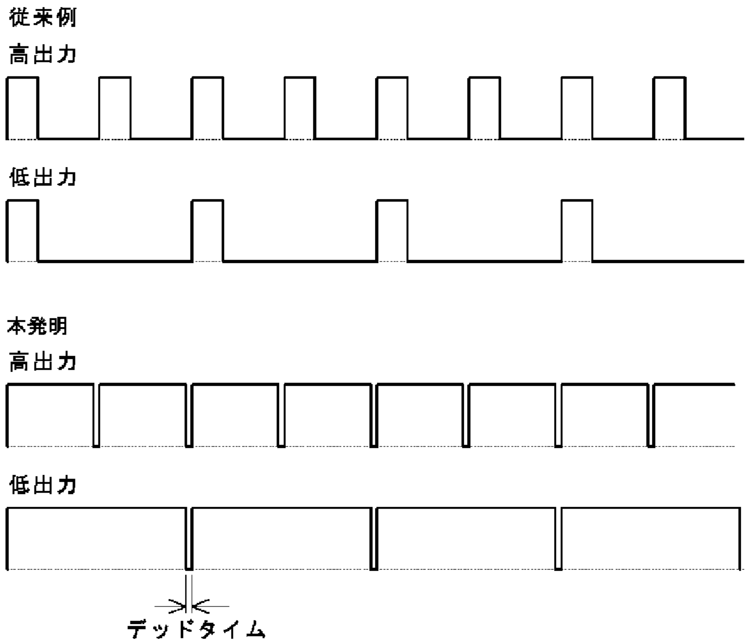
[Drawing 12]



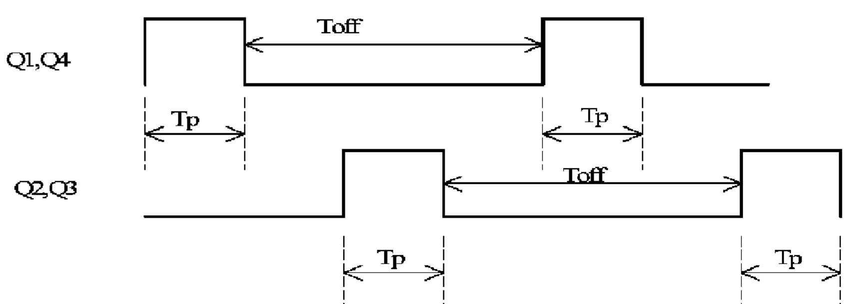
[Drawing 13]



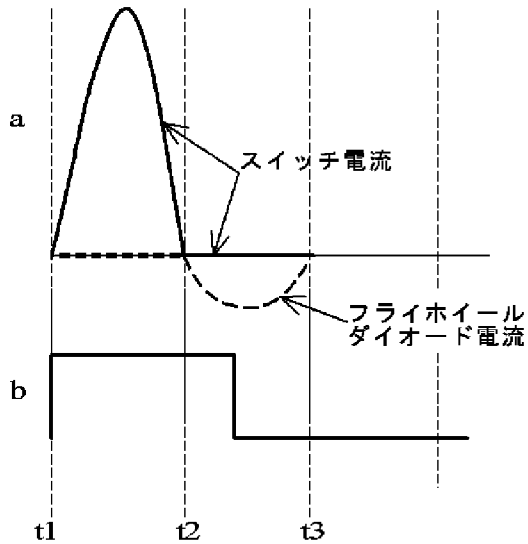
[Drawing 14]



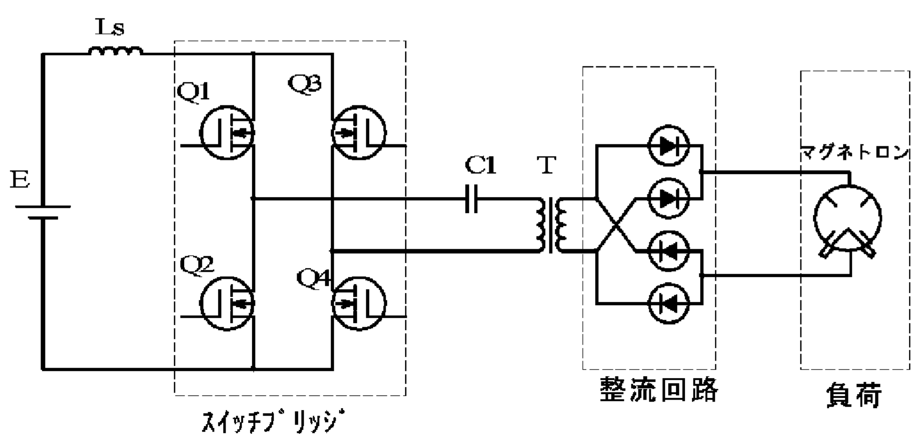
[Drawing 19]



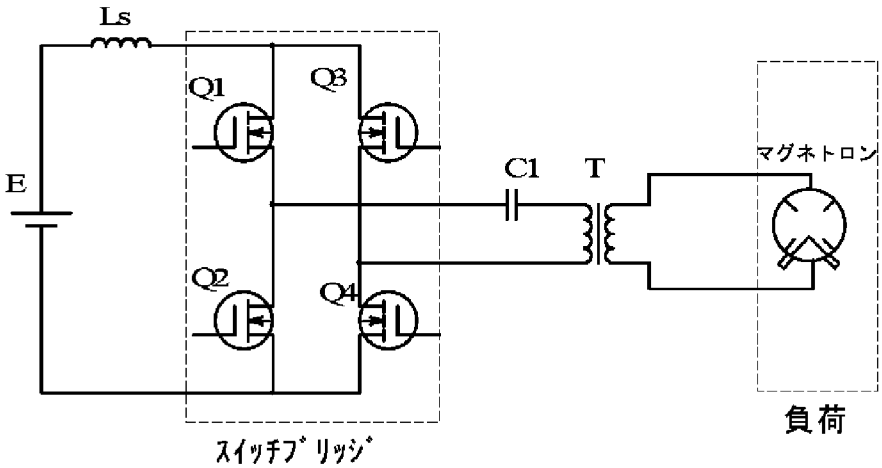
[Drawing 20]



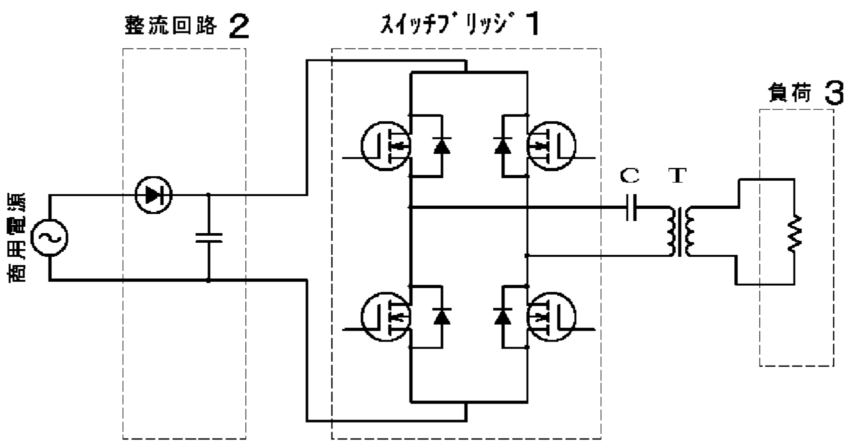
[Drawing 15]



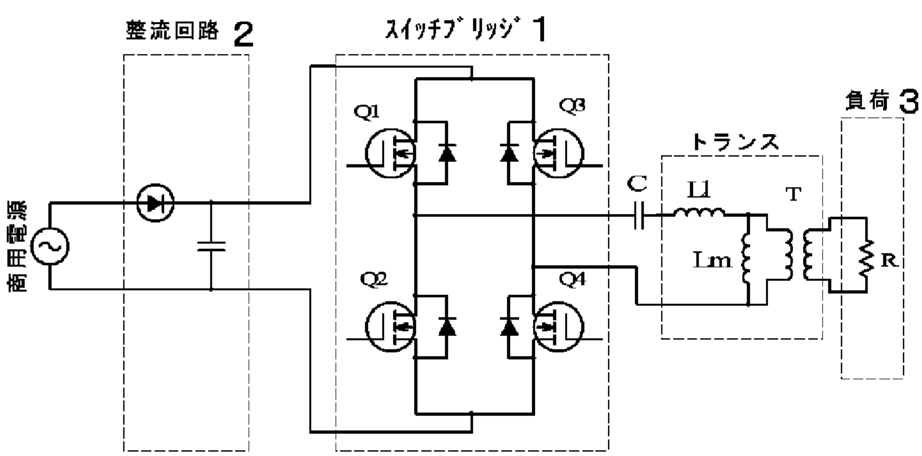
[Drawing 16]



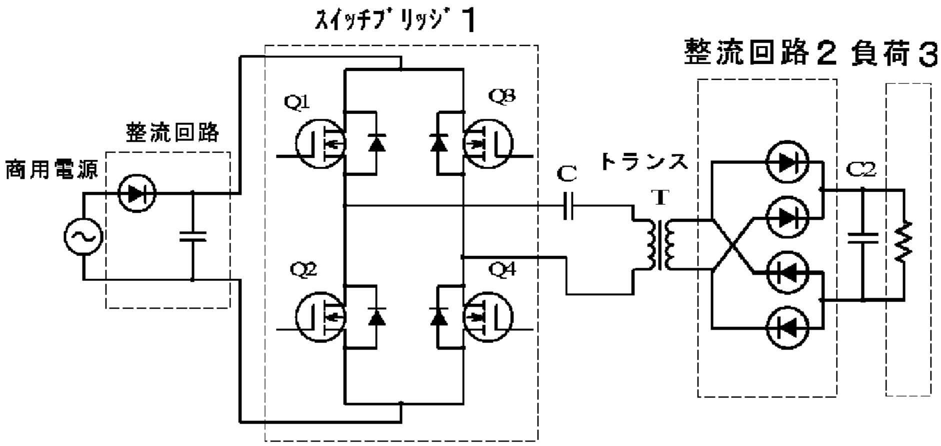
[Drawing 17]



[Drawing 18]



[Drawing 21]



[Drawing 22]